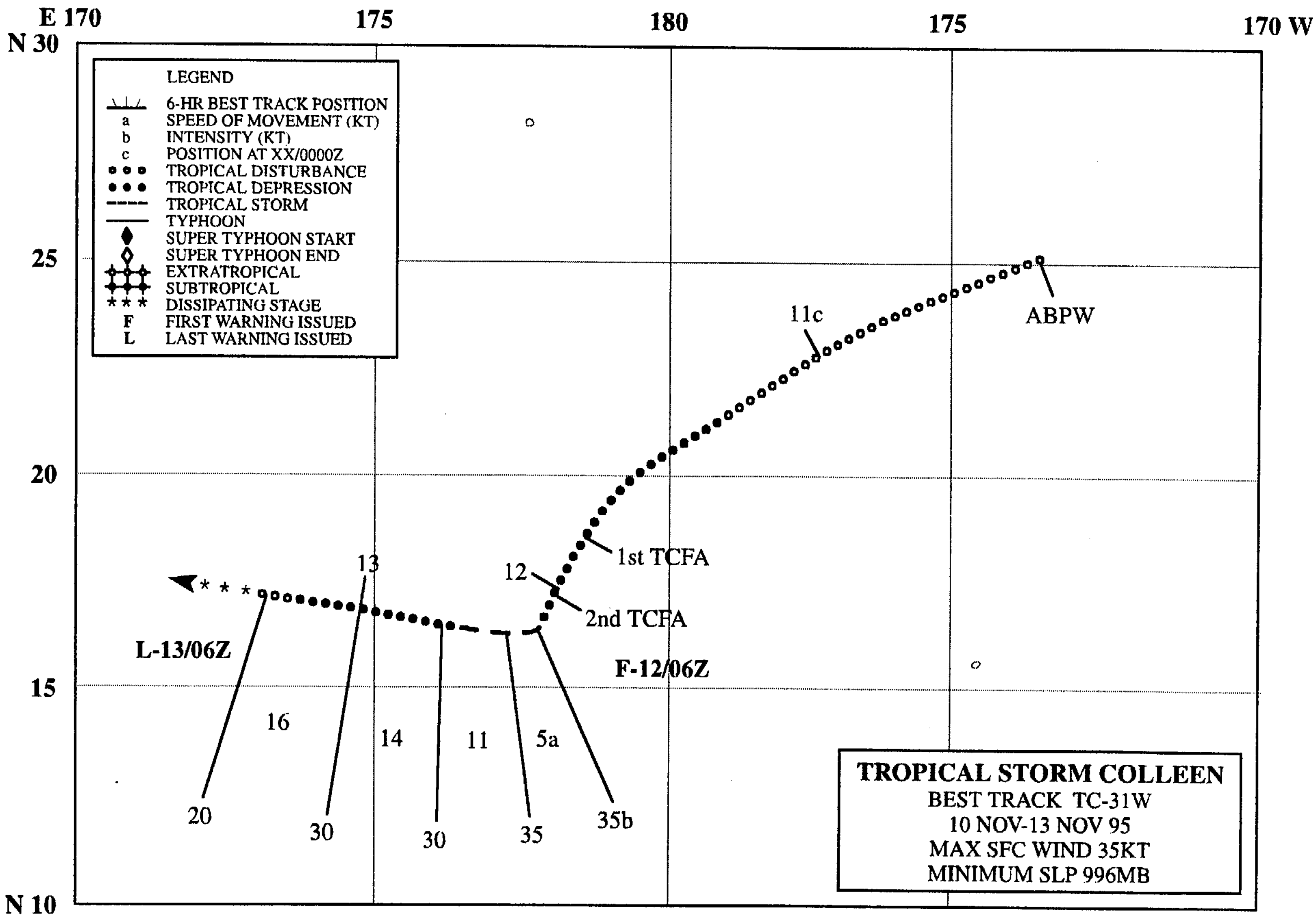
E 170
175
180
175
170 W
N 30
25
20
15
N 10
LEGEND
6-HR BEST TRACK POSITION
a SPEED OF MOVEMENT (KT)
b INTENSITY (KT)
c POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
SUBTROPICAL
DISSIPATING STAGE
F FIRST WARNING ISSUED
L LAST WARNING ISSUED
11c
ABPW
1st TCFA
12
2nd TCFA
13
L-13/06Z
F-12/06Z
16
14
11
5a
20
30
30
35
35b
TROPICAL STORM COLLEEN
BEST TRACK TC-31W
10 NOV-13 NOV 95
MAX SFC WIND 35KT
MINIMUM SLP 996MB

TROPICAL STORM COLLEEN (31W)

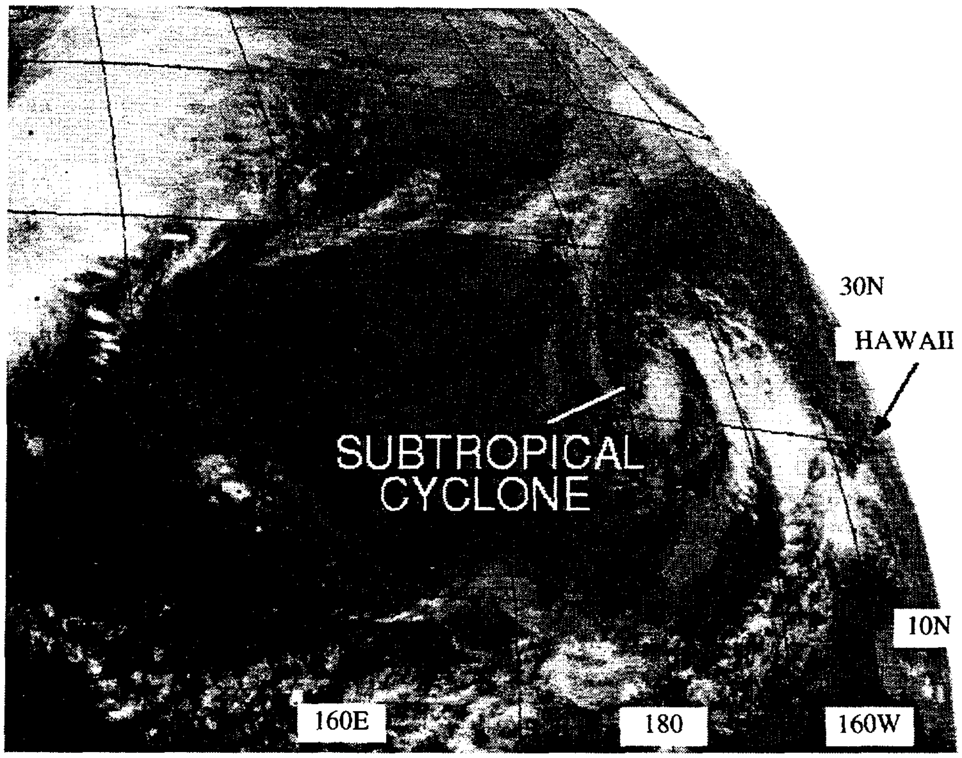

Figure 3-31-1 A "Kona" storm located to the west-northwest of Hawaii has just acquired central deep convection marking the beginning of its transition from a subtropical cyclone to a tropical cyclone (102332Z November infrared GMS imagery).

I. HIGHLIGHTS

Colleen developed in an unusual manner for a tropical cyclone in the western North Pacific. The disturbance that became Colleen was a cut-off low that formed in the subtropics to the northwest of Hawaii — a classic "Kona" low. Drifting toward the southwest, the "Kona" low crossed the international date line into JTWC's area of responsibility, where it acquired persistent central convection and became a tropical storm.

II. TRACK AND INTENSITY

On 09 November, a cold-core low pressure system became cut-off about 600 nm (1100 km) to the northwest of Hawaii. This system possessed the structural characteristics of a subtropical cyclone (Hebert and Poteat 1975). Such systems in the Hawaiian region are called "Kona" storms (Ramage 1971) in reference to their southwesterly winds that blow onshore in the normal leeward, or "Kona", sides of the islands.

After becoming cut-off to the northwest of Hawaii, the subtropical low (or "Kona" storm) that became Colleen began to drift toward the southwest, and on 11 November it crossed the international date line. Prior to crossing the international date line, the amount of deep convection began to increase near the low-level circulation center (Figure 3-31-1), prompting its first mention on the 110600Z Significant Tropical Weather Advisory. Remarks on this advisory included:

". . . A low-level circulation is located near 22°N 179°W. This area is associated with a subtropical low pressure system that has been moving southwest at 15 knots [28 km/hr] over the past 24 hours. Convection has increased, and is sheared to the east and south of the exposed low-level circulation . . ."

The system crossed the international date line at 110900Z. Shortly thereafter, based upon persistent convection near the low-level circulation center, and anticipation that the system would intensify, the first Tropical Cyclone Formation Alert (TCFA) was issued at 111930Z. A second TCFA was issued at 120100Z in order to reposition the alert area. Remarks on this second TCFA included:

"... A low-level circulation associated with a subtropical low pressure system has continued drifting south-southwest, and is showing signs of developing into a tropical cyclone. Convection is forming closer to the center of the circulation, which is well defined in the low-level cloud lines. ..."

During the daylight hours of 12 November, it was deemed by the JTWC that the subtropical low had become a tropical storm (Figure 3-31-2), and the first warning on Tropical Storm Colleen valid, at 120600Z was issued. Remarks on this first warning included:

"... Tropical Storm Colleen (31W) has formed from a subtropical low pressure system located northeast of the Marshall Islands. Colleen has been diving southward over the past twelve hours, but is expected to assume a westward track within 12 to 24 hours ..."

After becoming a tropical storm, Colleen did indeed assume a westward track. After turning toward the west, however, amounts of deep convection near the low-level circulation center decreased, most-probably as a result of increasing westerly wind shear on the system. By warning number 4 (valid at 130000Z), there was no organized deep convection associated with the system, however microwave imagery indicated that 30 kt (15 m/sec) sustained winds were still associated with the low-level circulation center. Tropical Storm Colleen was downgraded to a tropical depression at this time and, with continued weakening, the JTWC issued a final warning valid at 130600Z.

III. DISCUSSION

Subtropical cyclones, "Kona" storms, and tropical cyclones

Establishing the defining characteristics of a tropical cyclone is a challenging exercise. For purposes of public warning, the nature of tropical cyclones has been simplified to a stratification based upon intensity. In this simplified framework, the first stage toward the development of a tropical cyclone is the tropical disturbance. A tropical disturbance is a discrete system of apparently organized convection, generally 200 to 600 km in diameter, originating in the tropics or subtropics, having a non-frontal, migratory character and having maintained its identity for 12- to 24-hours (Elsberry, et al. 1987). The system may or may not be associated with a detectable perturbation of the low-level wind or pressure field. It is the basic generic designation which, upon acquiring a persistent low-level cyclonic wind field associated with an area of lowered sea-level pressure, becomes a tropical cyclone. In the United States, (TCs) are categorized by their intensity: (1) a tropical depression is a TC with maximum sustained one-minute mean surface winds (V1 Max) of less than 34 kt (17 m/sec); (2) a tropical storm is a TC with a V1 Max in the range of 34 to 63 kt (17 to 32 m/sec); (3) a hurricane (typhoon) is a TC with a V1 Max of 64 kt (33 m/sec) or more. In recent years, a fourth category — the super hurricane (typhoon) — has gained popular acceptance; it is a subset of the hurricane (typhoon) category with a V1 Max of 130 kt (67 m/sec) or greater.

Dvorak (1975, 1984) developed a technique for estimating the intensity of tropical cyclones from satellite imagery. His technique is used worldwide. In the Dvorak classification technique, persistent deep convection must be located within 120 nm (220 km) of the low-level circulation center in order to initiate classification. The intensity of the tropical cyclone is determined by several properties of the deep convection (e.g., the proximity of the low-level circulation center to the deep convection, the size of the central dense overcast, the cloud-top temperatures and horizontal width of the eye wall cloud, the width and extent of peripheral banding features, etc.). The basic tropical cyclone pattern types identi-

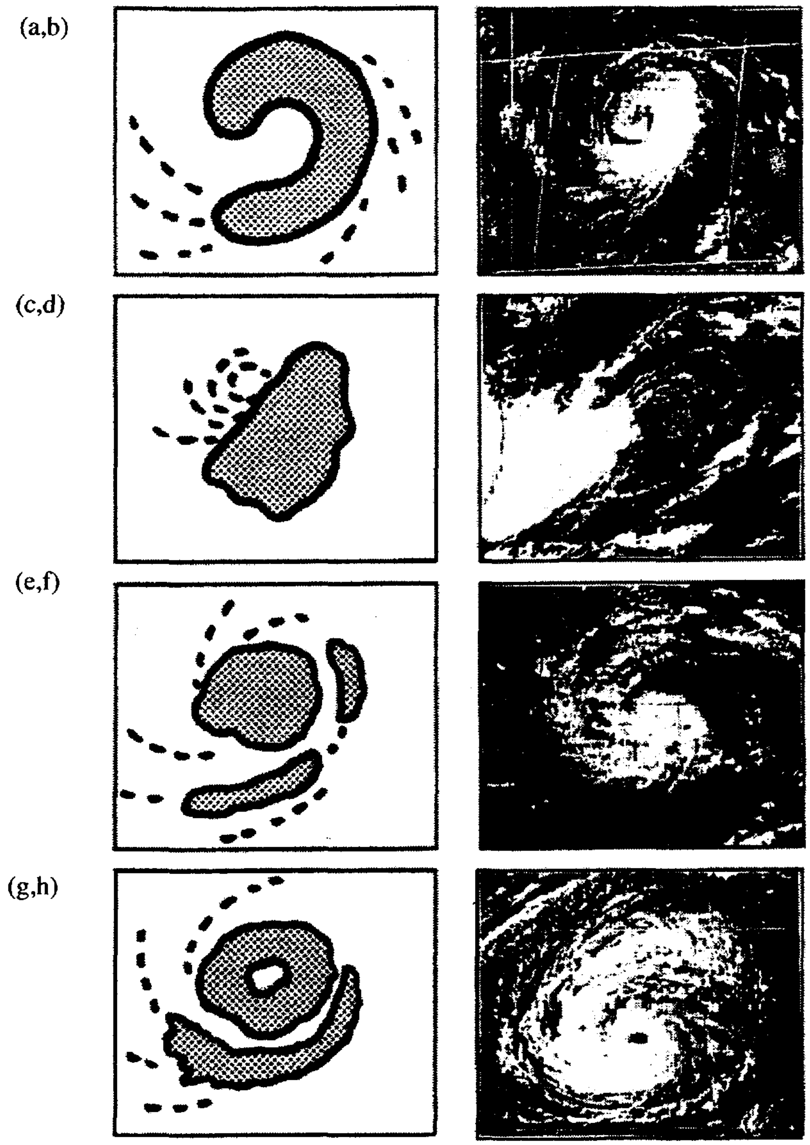

Figure 3-31-2 Schematic illustration (left column) and representative satellite imagery (right column) of Dvorak's (1975) basic tropical cyclone pattern types: (a,b) the "curved band" pattern; (c,d) the "shear" pattern; (e,f) the "central dense overcast" pattern; and, (g,h) the "eye" pattern.

fied by Dvorak are: (1) the "curved band" pattern (Figure 3-31-3a,b); (2) the "shear" pattern (Figure 3-31-3c,d); (3) the "central dense overcast", or "embedded center", pattern (Figure 3-31-3e,f); and, (4) the "eye" pattern (Figure 3-31-3g,h).

Some cyclones possess characteristics of both extra-tropical (ET) cyclones and tropical cyclones. For example, the subtropical cyclone (Hebert and Poteat 1975), the "Kona" storm (Ramage 1971), the arctic hurricane (Businger and Baik 1991), the monsoon depression (Ramage 1971, and JTWC 1993), and the monsoon gyre (Lander 1994, Carr and Elsberry 1994). These types of cyclones have caused diagnostic and forecast problems for decades. Further complicating things is the fact that transitions among some of the types are possible.

Because Dvorak's techniques are not applicable to subtropical (ST) cyclones, Hebert and Poteat (1975) (hereafter referred to as HP75) developed a satellite classification technique for ST cyclones. Their technique provides an intensity estimate (from satellite imagery) of ST cyclones, and provides guidelines for determining the cyclone type (i.e., tropical, ST or ET). The technique was designed so that the intensity estimate would intermesh with the Dvorak technique when the cyclone changed type.

For example, if a subtropical cyclone with an estimated intensity of ST 3.0 became a tropical cyclone, it would then be given a Dvorak "T" number of T 3.0.

HP75 identified three modes of origin for the ST cyclone: (1) high-level origin from an upper cold low; (2) low-level origin from a frontal wave; and (3) low-level origin east of an upper-level trough but not on a front. Determining when a ST cyclone becomes a TC is not clearly defined by HP75, but one of the criteria in Table 3-31-1 would seem to be the most definitive: the ST cyclone cannot have its center under central dense overcast. If it does, it should be classified as tropical.

Colleen developed when an upper cold low that cut-off to the northwest of Hawaii — a "Kona" storm — moved southwestward and acquired persistent central deep convection. "Kona" storms are primarily a feature of the winter weather of Hawaii. Occurring from about late October to mid-April, they rarely become tropical cyclones. The "Kona" storm that became Colleen is a good example of the transition of a subtropical cyclone to a tropical cyclone — a rare event in the North Pacific Ocean.

IV. IMPACT

No reports of damage or injuries attributable to Tropical Storm Colleen were received at the JTWC.

Table 3-31-1. Similarities and differences between the Dvorak technique for tropical cyclones and the technique of Hebert and Poteat (1975) for subtropical cyclones as adapted from Table 3 in HP75.

SIMILARITIES

(1) Uses convective overcast.

(2) Uses distance of the low-level circulation center from the convective overcast.

(3) The ST number features and associated intensities are selected to correspond to observed current intensity numbers so that ST numbers merge to Dvorak's T numbers when the system becomes tropical.

DIFFERENCES

(1) ST technique considers the environment in determining type.

(2) A subtropical cyclone cannot have its low-level circulation center under central dense overcast.

(3) The ST technique adds translation speed excess above 20 kt to cloud feature wind estimate.